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A Study of the Correlation of the Use of Visuals and Learning Elementary Science Vocabulary

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Abstract

This mixed methods study examines the correlation of effective visuals and science vocabulary acquisition and asks the question, "Does the use of effective visuals enhance science vocabulary acquisition and the resulting expression of that vocabulary?" Thirty-one students from two elementary schools in Clyde, North Carolina participated in this study and were randomly assigned to four different instruction interventions: a Word Only method, in which an oral presentation of the word was given; a Picture Presentation method, in which a word was paired with a picture; an Image Creation—No Picture method, in which the participants were required to create an image of the vocabulary word presented and draw it on paper; and an Image Creation—Picture method in which participants were presented a picture and required to draw it on paper. The results demonstrated that the intervention groups of Picture Presentation and Image Creation—No Picture consistently scored a greater cumulative mean on both an immediate recall assessment, conducted 24 hours following the intervention, and the delayed recall assessment, which was conducted two weeks following the intervention. Student perceptions gathered from open-ended interview questions further supported the interpretation that the use of visuals positively impacts student knowledge and effort.

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Chapter 1: Introduction to the Study

Visuals empower the minds of people from all walks of life. People must daily negotiate imagery in order to make sense of their actions. Everyone must rely upon written words and symbols—language—for guidance. Many people begin their day with a journey; they have a beginning point and a destination. Along this journey, road signs provide the language they need. Bus terminals, subways, train stations, airports, bicycle routes, and elevators provide, in the form of maps, signs, and diagrams, this language people have come to rely upon; the language known as visuals. Travelers must make sense of their journeys each day with the aid of visuals and imagery that accompany and, in some cases, replace the written language that guides people's paths. Travelers are neither cognizant of this medium, nor do they ponder its uses, though without visual language their day might be incomprehensible. People do, however, rely heavily upon its existence without stopping to consider the benefits. Visuals make a beautiful connection in the mind, allowing people to "see" with a new set of eyes: their mind's eyes. Imagery is personal. It is based on one's perceptions. Imagery is also vital to understanding. One can imagine before one can fully understand. In this manner, visuals are a doorway to understanding.

The journey of a student's academic career equally relies upon making connections between written words and imagery. Educators must open doorways to understanding. Teachers can open new doorways through the use of visuals. Teachers have long used visuals in the classroom, often without thought. Beginning with kindergarten and picture books, students have been exposed to visuals in one form or another during their academic career. No longer are teachers adding visuals to the lessons of the day solely for the purpose of giving the students something attractive to consider; instructors now purposefully and thoughtfully consider the effectiveness of visuals in the classroom.

Effective visuals require careful planning and thoughtful use, not only as a tool for the teacher to deepen the connections to content, but also as a means for student self-reflection and self-expression. Such self-awareness facilitates students' creation of personal doorways to understanding. When students come to class, they do not come empty handed. They enter with the most powerful processor known to mankind: the human brain (Schmidt, 2009). It is within this processor that connections are established and images are created.

The ability to establish connections and create images is invaluable to the elementary student, who must learn a challenging variety of content material. They are exposed to a great deal of this content material for the purpose of creating a hook on which these same concepts will catch as their academic career advances. Younger students must build a working vocabulary that will carry them through their courses, and, as such, it is imperative that they develop effective strategies for comprehension. Visuals are one such strategy. Visuals provide a fun, strong focus on vocabulary and help students communicate and comprehend (Cohen, 2012a).

Definition of Terms

Academic vocabulary. Refers to complex, sophisticated, content-specific vocabulary (DeLuca, 2010).

CCSS. Common Core State Standards (http://www.corestandards.org/, Retrieved 2014)

Effective measures. Measures of effectiveness. Tools used to measure results achieved in the overall mission and execution of assigned tasks. (thefreedictionary.com, Retrieved 2014)

ESOL. English for Speakers of Other Languages (DeLuca, 2010).

Disciplines. A branch of knowledge or teaching (thefreedictionary.com, Retrieved 2014).

Dual coding theory. The assumption that all cognition involves the processing of two independent yet interconnected systems; a nonverbal system that represents the perceptions of nonverbal objects and events, and a verbal system that deals with linguistic stimuli and responses (Paivio, 2010).

Mixed methods research. The broad type of research in which elements or approaches or other paradigm characteristics from quantitative and qualitative research are combined or mixed in a research study (Johnson & Christensen, 2008).

Quasi-experimental. An experimental research design that does not provide for full control of potential confounding variables primarily because it does not randomly assign participants to comparison groups (Johnson & Christensen, 2008).

Vocabulary acquisition. Gaining the words that make up a language, through the use of vocabulary instruction (Cohen & Johnson, 2012).

Statement of the Problem

The acquisition of vocabulary, particularly science vocabulary, may seem straightforward. However, academic language is a second language, and in the case of English for Speakers of Other Languages (ESOL) students, it is a third language (DeLuca, 2010). The science vocabulary that elementary students must absorb is not the language that they use on a daily basis. These terms are more sophisticated and are content-specific. Most elementary school students are unlikely to use science vocabulary terms in their social conversations. The technical and content-specific nature of science vocabulary terms makes them difficult to learn for many elementary students. The use of visuals can ease the learning of these technical terms for these students.

Recent studies have indicated that the use of visuals in the presentation of vocabulary produces greater acquisition for elementary students (Cohen and Johnson 2011, 2012; Cohen 2012b). Cohen and Johnson (2012) call for continued research and alternative methods of measurement to determine the depth of acquisition and retention. Typically, methods have included pre-tests to ascertain the base-line of students' science vocabulary knowledge. From these pre-tests, researchers conduct interventions. Following these interventions, researchers administer a post-test of their own design to the participants to measure growth, if any. However, the interpretations of these results have been complicated by the fact that these surveys do not account for participants' generation of the definitions of the vocabulary; the post-tests have used methods of multiple choice and matching, thus providing opportunities for recognition, not generation. Effectively implementing visuals should not halt at the evidence of content recognition; students respond to opportunities for deeper enrichment to stretch their intellect. The generation of definitions, in this instance, is an example of the fruit of that deeper enrichment. Goetz, Sadoski, Stricker, White, and Wang (2007) report that the effects of visuals used in conjunction with concrete imaginable terms results in an elevated quality of student-generated definitions. This study aims to report on the correlation between the use of visuals and the acquisition of science vocabulary while also asking the question, "Does the use of effective visuals enhance science vocabulary acquisition and the resulting expression of that vocabulary?"

Scope of the Study and Delimitations

Previous studies have established a correlation between the use of visuals in the classroom and students' recognition of science vocabulary definitions (Johnson and Cohen 2012; Cohen 2012b). The scope of this study considers the depth of that correlation. Vocabulary acquisition demands effective measures to guarantee depth of learning. It is not enough for students to possess a surface understanding of critical terminology in the content-specific disciplines. One measure of depth of understanding is when students can communicate their understanding in their own words. This study considers interventions that could lead to this depth.

Using similar methods to those of Johnson and Cohen (2012), this study diverges from their outcome measurements by seeking the generation of definitions of science vocabulary, rather than mere recognition. This study further diverges from the original study in that the target samples will represent elementary students from both a private school and a public school. With the inclusion of both demographics, the generalizability increases to include more than just the public sector, unlike the original study (Johnson and Cohen, 2012).

Although visuals are commonly perceived as any form of visual text, easily found in most classrooms around the globe, this study focuses on the use of pictures and words to determine depth of correlation. While academic vocabulary, as previously discussed, includes all disciplines in a student's academic career, this study targets the discipline of elementary science vocabulary. Students who gain a technique, like using the correlation of pictures and words, in a technical discipline such as science, can exploit that technique to other disciplines, both content-specific and non-content-specific disciplines.

Other delimitations are that this study collects data from only one grade level within the elementary school and from only two rural schools. This study targets only the fourth grade, although the fourth grade classroom in the targeted private school is a combination third/fourth classroom. Additionally, the entire combination class receives science instruction at a fourth grade level. Generally speaking, I selected fourth grade because it is a fair representation of an elementary grade without the students being deemed too young or too old within the limits of an elementary school setting. The lack of schools representing an urban setting was based solely on convenience. Additionally, the scope of this study cannot include all possible elementary grade levels and all possible demographics of private and public schools.

Significance of the Study

Some would argue that it is sufficient for students to display knowledge based on recognition. In other words, students need only to recognize correct information presented to them. The present study challenges this view as the possession of surface knowledge only. Depth of understanding occurs when students can create and generate knowledge. The depth required for this type of knowledge comes from rich educational experiences. The use of effective, efficient visuals can yield these rich experiences. The goal of this study is to determine the most effective, efficient use of science vocabulary visuals, based on four interventions that graduate in depth of processing.

The present study stretches student learning. Effective educators are actively engaged in methods to propel their students toward academic success. More importantly, students are subtly observing the models set before them in their respective classrooms. Educators who are assiduously crafting highly engaging learning activities are planting seeds of motivation within their students. The limits of student motivation are infinite. With this prospect of motivating students to heights unrealized, this study hopes to add significance to a researched strategy demonstrated as an effective method for producing rich depth of learning: visuals.

Methods of Procedure

Following an examination of current literature focusing on the effectiveness of visuals in the acquisition of science vocabulary, the present study, which was modeled after Cohen and Johnson (2012), was birthed. The present study seeks to report participant knowledge of elementary school science vocabulary based on participants' generation of the definitions, while lacking recognition opportunities and highlighting various depth of processing enrichment opportunities.

The study used a quasi-experimental, mixed-methods research model, randomly assigning participants to intervention groups. The participants were previously assigned to their classrooms at the beginning of the school year and full control could not be achieved because of these assignments, thus, the classification of a quasi-experimental research design. The four different intervention groups varied in depth of processing and use of visual imagery. Each intervention group participated in a pre-test, followed by their group's intervention and two ensuing post-tests. I conducted the tests to measure the effectiveness of each intervention: the pre-test, which I administered to provide a baseline of science vocabulary knowledge: the first post-test, which I administered 24 hours following the intervention to determine immediate retention: and the second post-test, which I administered two weeks following the intervention to measure delayed retention. Both the pre-test and post-tests required the participants to generate science vocabulary definitions for appropriate, predetermined science vocabulary, which I selected based on the objectives of the current science curriculum instruction each class was receiving. I used a Science Vocabulary Definition Three-Point Rubric (Appendix B) to measure the accuracy of the participants' definitions, which resulted in a numeric test score for each participant for each test taken. This data provided the basis of the quantitative data analysis. Additionally, I conducted student interviews with an oral, open-ended questionnaire to obtain student perceptions on procedures and content. The collection of this narrative data provided for the qualitative analysis of data.

Chapter 2: Plenary Literature Review

Today's Prescription for Content Knowledge

Today, students face the challenge of learning difficult and unfamiliar text, particularly in the disciplines of science and social studies. The Common Core State Standards are challenging students to increase their academic ability to comprehend and produce complex text (Hiebert and Pearson, 2012). The process for meeting this challenge includes reading—lots of reading. Researchers have investigated the types of text that best profit the students and have found that both fictional text and informational text may serve as a means for effective comprehension (Arya, Hiebert, and Pearson, 2011). Fictional text carries the perception of providing more engaging dialogue, thus resulting in student retention of important information. Students perceive informational text as dry and unappealing. Cervetti, Bravo, Hiebert, Pearson, and Jaynes (2009) report that these perceptions may not hold true, however. Researchers asked students to read both fictional and informational text and then assessed students' recall of predetermined objectives. Although they were lengthier, the responses to the fictional text objectives contained less relevant information required in the assessment compared to the responses to the informational text objectives. Additionally, students did not regard the challenging text as less captivating. One can conclude from these findings that entertainment does not always equal comprehension. The study does suggest, however, that concrete topics may provide a more concise understanding than abstract topics, and that the narratives in fictional text can complicate comprehension (Cervetti et al, 2009). Students, particularly young students, struggle with abstract ideas and tend to be concrete thinkers: they know what they experience. As they mature and contemplate the possibilities beyond their immediate experiences, they are more accepting of abstract topics, which further supports the evidence of concrete topics providing more concise understanding.

Informational science text, unlike narrative science text, not only introduces complex vocabulary, but repeats terms more frequently (Hiebert and Pearson, 2012). Because science vocabulary is complex, it necessitates repetition. Additionally, the Common Core State Standards call for students at the early elementary grade levels to begin their scaffolding of complex literature and informational texts, so younger students must now wrestle with difficult vocabulary (Hiebert and Pearson, 2012). The earlier the student is exposed to the vocabulary and continues to be exposed to it, the better the retention and imagery. McDonough, Song, Hirsh-Pasek, Golinkoff, and Lannon (2011) report that when children learn a word early in life, they produced enhanced mental imagery associated with that word. Many of these words are nouns. This is not to say that nouns are always easier to learn; nouns represent the majority of the concrete language to which children are exposed. Sadoski, Goetz, Stricker, and Burdenski (2003) found concrete words combined with the use of an imagery strategy consistently resulted in weightier definitions. Considering these results and the reality that science terminology includes concrete language, strategies for the acquisition of that terminology can capitalize on this research.

For students, prior content knowledge is as relevant as genre. When teachers provide purposeful, interdisciplinary, and content-rich selections of text that are a part of a systematic grade-to-grade curriculum, as the Common Core State Standards suggest, students will encounter a variety of topics and will experience more success when required to decipher complex text. They can draw on the prior knowledge they will have gained through this purposeful selection of texts (Hirsch and Hansel, 2013). Hiebert and Pearson (2012) argued that educators should view this approach not as the mere teaching of basic skills, but as powerful literature being the source of knowledge. Further, Arya, Hiebert, and Pearson (2011) examined the effects of syntactic and lexical complexity on third-grade students' comprehension of science texts and reported that prior knowledge of vocabulary may affect the lexical complexity for a student. Simply stated, students may find complex text easier to comprehend should they possess prior knowledge of that text. Teachers can ensure prior knowledge by regularly exposing students to the topics set forth by CCSS, beginning in early elementary grades and progressing through students' academic careers.

Science Vocabulary

Words are powerful tools, and they are foundational to knowledge. Words are used to communicate with others, access knowledge, express ideas, and learn new concepts (Jackson and Newell, 2012). Students are incessantly engaged in communication for numerous reasons. Social communication requires students to use and understand words, as does accessing knowledge and learning new information, all of which propel students toward vocabulary understanding. Words are an integral component of a student's daily regimen. Success depends, for the student, on the mastery of the vocabulary they encounter in their various social and academic settings. Mastery of that vocabulary is necessary not only for daily communication. It is vital for learning in all disciplines. Many educators recognize the value of carefully engineered lessons to aid their students in the acquisition of this vocabulary. A variety of effective strategies has provided evidence of their success. These strategies include, but are not limited to, the use of mnemonics to foster memory and heighten vocabulary learning (Amiryousefi and Ketabi, 2011), Poker-type card games using pictures to learn English (Meihua, 2009), and classroom posters combined with self-directed learning (Cetin and Flamand, 2013).

Educators actively seek effective methods by which their students can learn the required vocabulary while enjoying themselves. Each discipline presents its unique challenges to the mastery of its vocabulary. The discipline of science is no exception. Science requires a large base of academic language. Academic language is English language that includes the nuances of social language but also incorporates sophisticated, content-specific vocabulary. Science textbooks are brimming with more sophisticated vocabulary than any other content area (DeLuca, 2010). The acquisition of science content rests upon the comprehension of the associated vocabulary. Without a command of the vocabulary, students cannot master the content (Cohen, 2012a). Therefore, students face the requirement of building the academic vocabulary essential to science instruction (Jackson and Narvaez, 2013). Typically, science instruction includes the use of a textbook or other printed text that the students must read and comprehend. Without a clear understanding of the academic vocabulary presented, the students will not succeed.

Vocabulary knowledge is elemental to the comprehension of text (Wessels, 2013). For this purpose, educators are using the strategies of visuals and imagery in science classrooms. They are considering alternatives to rote memorization and assigned reading, and they must, therefore, think differently about teaching science (Fisher and Blachowicz, 2013). Visuals offer an alternative to the traditional approaches to presenting science vocabulary: an engaging visual clue for student recall. Some educators have dedicated “word walls,” on which they display words as they introduce new vocabulary within the boundaries of the new concepts of the lesson. These vocabulary word walls help in the students’ review of the spelling of the words, but do not present a visual image connected to the meaning of the vocabulary word. A pictorial image can connect the meaning to the word and aid in its mastery (Cohen, 2012).

Teachers must take care in this seemingly straightforward approach, however. Many times, educators fall prey to tunnel vision in reference to learning strategies—in this case, visuals—and are blindsided when their students do not achieve the levels of success anticipated. This can occur when the teacher makes assumptions concerning their students' learning. Students, particularly younger students, do not have the language experiences that teachers have had, or expect them to have had. Consequently, students do not understand everything that their teachers say, although students may indicate otherwise. To further complicate the teachers' expectations of learning, children cannot always visualize oral language, nor do they necessarily apply background knowledge that would aid in their learning (Cochrane, 2013). In light of these challenges, image-based education demands development and use of both efficient and effective visuals based on current research on human learning (Schmidt, 2009).

Dual Coding

One such study involved dual coding theory. The inclusion of both verbal and visual stimuli in the introduction of vocabulary will enhance student learning. Paivio (2010) reports that dual coding occurs in all cognition. In an earlier work (Paivio, 1971), his groundbreaking findings were foundational for the theory that the human brain processes information through the interrelationships of both verbal and visual elements. This relationship is accomplished through an exchange of verbal codes and nonverbal codes. Verbal codes relate to linguistic verbal communication, while nonverbal codes relate to nonverbal linguistic communication, and though these are separate entities, they join together. Nonverbal codes are like imagery codes, as creating mental images is their primary function (Dolati and Richards, 2012). Stated simply, mental representations are created at the point of learning. Learners can create mental sketches or even mini movies that the mind encodes at the time of learning and subsequently retrieves when necessary (Wilson, 2012). The human brain powerfully processes sensory information, particularly visual information, and if educators can harness that power, their teaching can facilitate changes in the learners' brains (Schmidt, 2009).

Students' Interest and Limitations

A further area of concern for educators is the antagonism demonstrated by students who do not hold an interest in science. This antagonism poses a complex challenge for educators in that they are not only striving to stretch the students' academic intellect, but also face the opposition to the content. Many students do not enjoy the content disciplines, such as science, and are reluctant to engage. Recent research points to various explanations of this reluctance, including, but not limited to, difficulty of subject matter, demands of student time in learning science, less practicality, broadness of science content, lack of sponsorship for science students, and the methods of knowledge transmission from the teacher/text to the student (Adu-Gyamfi, 2013). Many students believe that science is uninteresting, difficult to understand, and irrelevant to everyday life (Aschbacher, Ing, and Tsai, 2013). Willsher and Penman (2011) conducted a study in rural Australia for the purpose of bringing science instruction opportunities to students who lived in an isolated, impoverished region and had not received effective science instruction. The results supported positive student learning, as well as teacher enrichment, through meaningful real-life activities with professional scientists.

While many schools may not or cannot employ the aid of professional scientists in the classroom, teacher and parent involvement can boost interest in science. Many students lose interest in science after middle school because of poor science instruction and an overabundance of afterschool activities (Ashbacher et al, 2013). Educators must capitalize on in-school instruction to positively influence student's perceptions of science.

In order to improve in-school science instruction, Ashbacher et al (2013) suggest establishing deeper teacher understanding of science content and incorporating scientific practices for better instruction with the use of effective vocabulary scaffolding while developing confidence in the students. Considering scaffolding new vocabulary and building confidence in the students, educators are utilizing visuals to build the bridge between difficult academic vocabulary and student perceptions concerning complex text. Ulbig (2009) reports better student attitudes toward college level political science issues following the intervention of the use of enhanced visuals. Given these conclusions, her study builds anticipation for the use of enhanced visuals in additional content disciplines, such as science.

While the prospect of using effective visuals in the classroom may excite educators of varied disciplines, all students may not benefit from their use. Booth and Koedinger (2012) experienced these results in their study concerning the use of problem-solving diagrams in the discipline of mathematics. The introduction of complex diagrams in middle school math posed a challenge for the younger middle school-aged math students. As students developed knowledge of abstract ideas through problem-solving as they progressed from sixth to eighth grade, however, their ability to take advantage of diagrammatic features grew. Educators' must consider of the use of visuals in relation to students' age-related development. Teachers must ensure that the visuals fit the students, avoiding inappropriate strategies that fail to account for student development levels.

Effective Visuals

While educators must consider the timing and appropriateness of visuals, they must also ask, “What constitutes an effective visual?” According to Katsioloudis (2010), valid indicators of effective visual-based learning materials, specifically for technology Education in grades seven through twelve, include the following:

- the amount of detail included in the visual,
- the varied instructional method used with the visual,
- students’ engagement and interest level,
- the method of objective presentation,
- the technique used for focusing student attention on the learning characteristics in the visual,
- the assessment type for evaluating student learning,
- the instructor’s ability to effectively and efficiently integrate the visual into the classroom environment and curriculum,
- time spent on background knowledge
- the quality of the visual,
- the student’s ability to integrate the visual-based material into the classroom environment and curriculum,
- the relevance of the visual,
- the direct correlation between the visual materials and the learning objective,
- the level of technology available to the student, the hardware being used by the student, and

- the teacher's confidence in the area of the visual teaching (Katsioloudis, 2010).

The results from this study clearly represent findings related to middle and high school level technology education classrooms, but can certainly apply to any discipline in which the instructors might supplement the lesson with visuals. Teachers would only benefit from these considerations when applying visuals as learning materials in their own classrooms.

Teacher-created visuals as learning materials can take many forms and can be very effective. Student-created visuals can be equally effective. Rowsell, McLean, & Hamilton (2012) illustrate the power of visuals and their ability to bring life to literacy in the classroom. As students create, opportunities arise for connections across disciplines. Not only can teachers lead students in discussions about what they see on the visual, but they can also connect students to other perspectives and topics related to that particular visual. Additionally, these discussions can lead to reflections concerning cultural issues. Even further, students might examine how visuals function as an expression of cultural identity. Teachers desire that their students create and express opinions and support their critiques, and this can happen with practice and guidance in the classroom using visuals as a platform for discussions. In this sense, teachers are encouraging their students to become critical consumers and producers of visual text (Rowsell et al, 2012). The benefits of implementing visual literacy in the classroom are indisputable: details that draw the reader/observer in for a more thorough analysis, greater motivation and self-direction for the students, and increased interaction with their real-world and cultural texts.

These studies prove that visual literacy in the classroom merits further study for the benefit of elementary students. One such effort would include synthesizing elementary students' exposure to science vocabulary and the use of visuals, which could lead to greater depth of understanding. This depth of understanding can lead to deeper communication of the learned content, and one example of this would be student-generated definitions of vocabulary. As such, the present study utilizes interventions which build in complexity of processing to measure student outcomes of science vocabulary acquisition and generation of definitions.

Chapter 3: Methodology

Population of the Study

Following approval from the Cedarville Institutional Review Board, I recruited participants from a private school in Haywood County, North Carolina and a public school in Haywood County, North Carolina. I mailed a letter to the private school's headmaster and the public school's principal describing the research and requesting permission to conduct the study at these educational facilities. With the headmaster's and principal's permission, I then distributed parental/guardian permission forms and solicited students for their assent. To ensure confidentiality, I assigned identification numbers to participating students using a table of random numbers to provide for random sampling. I placed the list of names and numbers for each class in a sealed envelope and stored it separately from the interventions and outcome measurement materials.

The targeted samples of this study consisted of an elementary combination class at a private school containing students from grades 3 and 4 with a student body of 14 students and a grade 4 elementary class at the public school with a student body of 18 students. With a relatively small student population at the private school (119 students in grades Pre-kindergarten through 12), combination classes are the standard. During the course of this study, one student from the private school combination class was consistently absent on each day of data collection. This student was, therefore, omitted from the study. As a result, I collected data from 31 students—13 girls and 18 boys. The mean age of the students was nine years and six months.

The private school grade 3/4 combination class was receiving instruction in the discipline of science at a grade 4 level, according to the objectives set forth by the North Carolina Essential

Standards for Grade 4, as was the public school grade 4 class. The gender ratio of the participating students of the private school grade 3/4 combination class was 4 girls and 9 boys, and the gender ratio of the public school Grade 4 class was 9 girls and 9 boys. In terms of ethnicity, 100% of the sample class at the private school was Caucasian, and 88.9% of the sample class at the public school was Caucasian, with 11% being Hispanic. I administered a demographic information query to all consenting students to determine age, gender, and number of languages spoken. No specific demographic differences emerged, with the exception of two students indicating their ability to speak two languages.

Design of the Study

I utilized a quasi-experimental, mixed-methods research design for the purposes of this study. I randomly assigned participants to one of the four different interventions by placing all random numbers assigned to the students in a hat and drew them out one at a time, but I could not randomly assign students to classrooms, as these were intact. I asked students to participate in a researcher-developed pre-test and post-test, with interventions transpiring in the interim. The independent variable in this study was the interventions, which varied on depth of processing and use of visual imagery. The dependent variable was vocabulary acquisition, which I measured by two different tasks: student generation of the vocabulary definitions and student perceptions of the effectiveness of visuals. I administered two post-tests: an immediate recall post-test, which I administered 24 hours following the interventions, and a delayed recall post-test, which I administered two weeks following the interventions. Following the delayed recall post-test, I interviewed participants using open-ended questions concerning their perceptions of the utility of the interventions.

Procedure

I selected 25 science vocabulary terms from the North Carolina Essential Standards for Grade 5 Science (2011). I chose nouns for easy visualization, and I selected words at a grade level higher than what participants had been receiving. In other words, the 25 vocabulary terms selected for both the private school grade 3/4 combination class and the public school grade 4 class were at a fifth grade level. I generated a definition for each word from either Merriam-Webster's Online Dictionary (2014) or Pearson Education's Glossary of Biology Terms (2009) and simplified as needed to ensure appropriate grade level understanding of each word. Additionally, I created simple sentences illustrating the use of each word. Independent from the study and having no knowledge of the specific research question, the private school's curriculum director and a fourth grade teacher from the public school reviewed these definitions and sentences to further ensure appropriateness. I found pictures for the picture presentation portions of the study through Google image searches. The pictures were printed in color and pasted onto one side of a five inch by eight inch index card. I printed the vocabulary word in black ink with a bold font of Calibri and a font size of 24 and pasted it to the other side of the corresponding index card. I then laminated each index card. See Appendix D for sample picture cards used for the interventions.

I included the 25 science vocabulary terms in a researcher-designed vocabulary pre-test I administered to the students. The test consisted of all 25 vocabulary words with the directions to generate the definition of each (See Appendix A). I used a Science Vocabulary Definition Three-Point Rubric to assess the generated definitions (See Appendix B). I used this same rubric to assess the generated definitions on both of the post-tests, the immediate response post-test as well as the delayed response post-test. I instructed the students not to worry if they did not know the vocabulary word(s) because these words were from a fifth-grade level, and they were difficult. Following this pre-test, I selected the 16 words with the highest percentage of incorrect answers for the interventions for each class.

I utilized four instructional interventions for this study: a Word-only method, in which I showed the word, pronounced it, presented it in a sentence, presented the definition, showed the word again, and repeated the process; a Picture Presentation method, in which I paired a word with a picture, showed the word, showed the picture, pronounced the word, presented it in a sentence, presented the definition, showed the word again, and presented the picture again; an Image Creation—No Picture method, in which I showed the word, pronounced it, presented it in a sentence, presented the definition, showed the word again, and then instructed the participants to create an image for the word and draw it on paper; and an Image Creation—Picture method, in which I showed the word, pronounced it, presented it in a sentence, presented the definition, and presented the participants with a picture of the vocabulary word and then instructed them to draw it on paper. To equalize the exposure to the words, I held the amount of time for the interventions at a constant 30 seconds. This includes students I had asked to generate a picture: I gave them 30 seconds in which to create their pictures before the next word was presented. I produced the pictures that accompanied the Picture Presentation method and the Image-Creation Picture method through a Google image search. Each image was printed in color and pasted onto a five inch by eight inch index card. The reverse side of the same index card showed the vocabulary word in bold lettering. Each card was laminated.

Within each class, students who obtained parental permission and assent to participate in this study were randomly assigned to one of the four intervention groups. I provided training to each group prior to the beginning of their intervention. I showed each group a picture of a familiar noun, a dog. Each intervention group practiced the expected procedure for their group. For instance, I showed the Word-only group the word “dog” on an index card. I pronounced the word, “dog,” used it in a sentence, gave the definition, showed it on the index card again, and repeated the word again. I repeated this method for each intervention group based on the intervention format for each particular group.

Following the interventions, I administered an immediate recall measure, the post-test, 24 hours following the interventions. Two weeks after the initial vocabulary instruction, I re-administered the post-test to measure retention again: the delayed recall measurement. I utilized the same format for the post-tests as for the pre-test, the difference being that the post-test was comprised of only the 16 science vocabulary words the groups encountered during their interventions. Likewise, I utilized the same Science Vocabulary Definition Three-Point Rubric (Appendix B) for the post-test outcomes as for the pre-test outcomes. Following the delayed recall outcome measure, I conducted informal interviews using open-ended questions (See Appendix C), to collect data concerning student’s perceptions on the potency of the methods used.

This study focuses on vocabulary acquisition and effective measures. I determined vocabulary acquisition and effective measures by varying methods: both the post-tests and the student perceptions. I assessed students’ acquisition and retention of the science vocabulary using an experimenter-designed vocabulary comprehension test in which the students generated the definitions of each vocabulary word they encountered in their intervention. Effective measures were, additionally, gauged on student perceptions following the delayed recall post-test. I collected and analyzed data through participant interviews utilizing open-ended questions. These results helped to clarify the effectiveness of the interventions and should provide guidance for educators as they seek to teach science vocabulary more successfully.

Pilot study. I conducted a pilot study with the Grade 5 class at Haywood Christian Academy. Participants in the pilot study represented varying academic levels within the fifth grade. The class consisted of five girls and eight boys, 100% of which were Caucasian. I followed the same procedures for the participants of the pilot study as for the participants of the actual research study. After administering the pilot study, I changed certain aspects of the study. Firstly, I modified the definitions of “ecology,” and “ecosystem,” to reflect a more student-friendly version of the definitions. Secondly, I changed the student assent form to reflect the recording of student demographic information.

After the pilot, I also realized the importance of carefully assigning random numbers to participants. The pilot study served as an indicator of how easily one might assign two participants the same random number. Consequently, I learned to prioritize this step in the actual research study. Additionally, I came to appreciate that I must carefully assign participants to the intervention groups. The pilot study, again, served as valuable practice for this step as I had omitted one participant from the assignment of an intervention group, which I quickly corrected.

Another important discovery in the pilot study was the setting in which to conduct the interventions. During the pilot study, I asked participants to enter a hallway adjacent to the fifth grade classroom, according to their intervention group, to participate in their intervention. I chose the hallway due to lack of additional space, and this choice resulted in many distractions for the participants. I sought a more secluded location for the interventions during the actual research study, securing a secluded hallway at the private elementary school and a secluded corner of the library at the public elementary school.

Data collection method. I used two types of data collection in this study: an experimenter-designed vocabulary comprehension test in which the students generated the definitions of each vocabulary word they encountered during their intervention (Appendix A), and participant interviews using open-ended questions (Appendix C). I retrieved quantitative data by assigning a numeric score to the responses on the experimenter-designed vocabulary comprehension tests based on a Science Vocabulary Definition Three-Point Rubric (Appendix B). I designed the interview questions as open-ended questions so as to construct qualitative data from the responses.

Relevant ethical considerations. This research posed no harm to the participants involved. I informed participants that I had received consent for their participation from their principal, their teacher, and their parent/guardian. I then gave each participant the opportunity to sign an assent form confirming their desire to participate in the study. No one refused to participate in the study: 100% of the participants chose to sign the assent.

Independent variable. The independent variable was the intervention. I assessed the four interventions using the numeric scores assigned to both of the post-tests: the immediate recall post-test and the delayed recall post-test. I also noted participant perceptions concerning the content of the interventions, as well as the procedure of the interventions.

Methods of data analysis. I based the quantitative analysis of the collected data on a numeric score that I had assigned to each participant's response. I assigned a numeric score to all of the assessments, the pre-test assessments and both post-test assessments. I assigned this score according to the quality of participants' responses as defined by the Science Vocabulary Definition Three-Point Rubric (Appendix B). Once I had assigned the scores, I then categorized all assessments as a pre-test, immediate response post-test, or delayed response post-test, and further separated them into groups based on the four intervention methods. I entered all test scores into Microsoft Excel spreadsheets based on the category of pre-test, immediate recall post-test, or delayed recall post-test, as well as the intervention method. In order to compare the test scores of the pre-test and post-test responses, I performed a one-way ANOVA. I also utilized a one-way ANOVA to compare the post-test scores of the four different interventions. The one-way ANOVA also served to test the statistical significance of the four intervention methods I utilized in this study. .

In order to analyze the qualitative data, I used a three-tiered coding system. First, I performed "open coding" by giving labels to describe the responses given by the participants. Next, I performed "axial coding" by looking for similar labels and grouping them into common categories. In this stage, I removed responses that did not commonly appear and added new categories for those that appeared often. Lastly, I performed "selective coding" by looking for any general themes that might have appeared from the common categories.

Safeguards to internal and external validity. I carefully constructed the experimenter-designed vocabulary comprehension test that I used in this study for simplicity and ease of use. I created all questions to elicit the participant's generation of vocabulary knowledge. I monitored all participants and instructed them to work independently, not allowing for collaboration on responses. I collected all post-tests and placed them in labeled folders for analysis at a later date to provide for anonymity on behalf of the participants. I interviewed each intervention group as a whole concerning their perceptions of the interventions. I recorded on paper every response given by a participant, placed it in a labeled folder, and later analyzed it to provide for further anonymity for the participants. All members of the population had equal opportunity to participate, so the sample showed no bias.

The results of this study could be generalized to similar rural fourth grade classrooms. It may not, however, be appropriate to generalize the results to fourth grade classrooms differing significantly from the study sample. I utilized a relatively small population at two rural elementary schools based on accessible population. The sample in this study is indicative of the area's rural elementary school population; the area's elementary classrooms possess a larger percentage of Caucasian students and a minority population of Hispanic students. Elementary schools in urban areas and even those elementary schools currently using a different course of instruction for fourth grade science may use this study as a launching pad for their own study, but may not consider the results of this study as applicable; the objectives set forth by the North Carolina Essential Standards for Grade 5 Science were the basis of the content in this study. Other elementary schools using another source for their objectives may wish to consider conducting their own research.

Chapter 4: Results and Analysis

Overview

This study sought to report on the correlation between the use of visuals and the acquisition of science vocabulary and asks the question, "Does the use of effective visuals enhance science vocabulary acquisition and the resulting expression of that vocabulary?" I explored this correlation by measuring the most effective, efficient use of science vocabulary visuals based on four interventions that graduated in depth of processing. The four interventions were the Word-only method, in which I showed the word, pronounced it, presented it in a sentence, presented the definition, showed the word again, and repeated the process once more; a Picture Presentation method, in which I paired a word with a picture, showed the word, showed the picture, pronounced the word, presented the word in a sentence, presented the definition, showed the word again, and presented the picture again; an Image Creation—No Picture method, in which I showed the word, pronounced it, presented it in a sentence, presented the definition, showed the word again, and instructed the participants to create an image for the word and draw it on paper; and an Image Creation—Picture method, in which I showed the word, pronounced it, presented it in a sentence, presented the definition, presented the participants with a picture of the vocabulary word, and instructed them to draw it on paper. Quantitatively, the intervention comparison results indicated no significant statistical differences for either post-test: the immediate response post-test or the delayed response post-test. At immediate response recall and delayed response recall, however, the mean for the Picture Presentation method emerged as the greatest mean of all four intervention methods, indicating that the participants in this intervention group benefited the most from their intervention method. Likewise, when comparing the one-way ANOVA results of the pre-test scores to both recall scores—the immediate recall post-test scores and the delayed recall post-test scores— the means of both of the recall post-tests increased from the mean of the pre-test, indicating that the four intervention methods aided in the increase of the post-test scores.

Participant responses to the open-ended survey further indicated that the students assigned to the Picture Presentation method benefited from this intervention method. Many participants in this intervention group responded positively to the Picture Presentation method, indicating that they saw the benefit of viewing a picture that represents vocabulary terms. Many further stated that they felt the Picture Presentation method boosted their ability to remember the vocabulary in the long term.

Intervention Effects: Data, Analysis, and Perceptions

An experimenter-designed vocabulary comprehension test, in which the students generated the definitions of each vocabulary word, was the basis of the pre-test as well as both post-tests. The tests differed in that I asked the participants to generate the definition for 25 predetermined science vocabulary terms on the pre-test, while the post-tests contained only the 16 most frequently incorrectly answered vocabulary terms. The 16 most frequently incorrectly answered vocabulary terms also served as the vocabulary focus for the intervention methods for each classroom. I used a one-way ANOVA to compare the test results of the pre-test and both post-tests—the immediate recall post-test and the delayed recall post-test. Additionally, I formulated descriptive statistics for further data analysis. The follow-up pairwise comparisons (see Table 1) between the post-tests indicated that participants generated significantly different definitions from those on the pre-test. The interventions positively impacted the participant's ability to generate the definitions of the science vocabulary from their intervention. Although not all four interventions involved the use of a visual,

Table 1

Pairwise Comparisons of Pre-test and Post-test Test Scores for Science Vocabulary Definitions

	Science Vocabulary Definitions		
	Pre-test (n=31)	Immediate Recall (n=31)	Delayed Recall (n=31)
Mean	2.32	6.84	4.74
Standard deviation	2.97	6.15	5.26

the Word-only method being the exception, student perceptions remained positive concerning the four different intervention methods in general. When I asked what was helpful during the intervention, I coded and recoded the same response on more than one occasion, a response that exemplified participants' positive perception:

> *"You telling us the definitions of the words."*

This perception was a key theme of the Word-only intervention group. Another key theme that surfaced during interviews was participants' use of prior knowledge in the generation of the definitions for the post-tests. When I asked what was helpful in remembering the definitions for the post-tests, one participant responded with the following:

"I went back to when my mom was practicing her science lessons for teaching her class, and I remembered some of the definitions."

The quantitative data supports the positive perceptions of the interventions as a whole. The average test score on the pre-test was 2.32 points out of a possible 48 points, whereas the average increased by 4.52 points on the immediate recall post-test and 2.42 points on the delayed recall post-test.

Intervention Comparison: Data, Analysis, and Perceptions

Immediate recall acquisition. The means (with standard deviations in parentheses) for Word-only, Picture Presentation, Image Creation—No Picture, and Image Creation—Picture interventions at the time of the immediate response assessment—24 hours following the intervention—were 5.5 (3.66), 11.25 (7.63), 5.83 (5.38), and 4.78 (5.87), respectively. Trends in the means indicate a difference in the acquisition of science vocabulary definitions based on the four interventions utilized. Intervention two, the Picture Presentation method, produced the greatest average of correct responses on the immediate recall post-test. Intervention three, the Image Creation—No Picture produced the next greatest average of correct responses on the immediate recall post-test. Therefore, the following pattern emerged: Picture Presentation > Image Creation—No Picture > Word-only > Image Creation—Picture. These relationships are visually represented in Figure 1. Participant perceptions recorded at the time of the interviews provide further support for the trend that surfaced. A key theme that emerged from the participants of the second intervention, the Picture Presentation method, was that they looked favorably upon the visuals: the pictures of the science vocabulary terms. One such participant expressed this favor as:

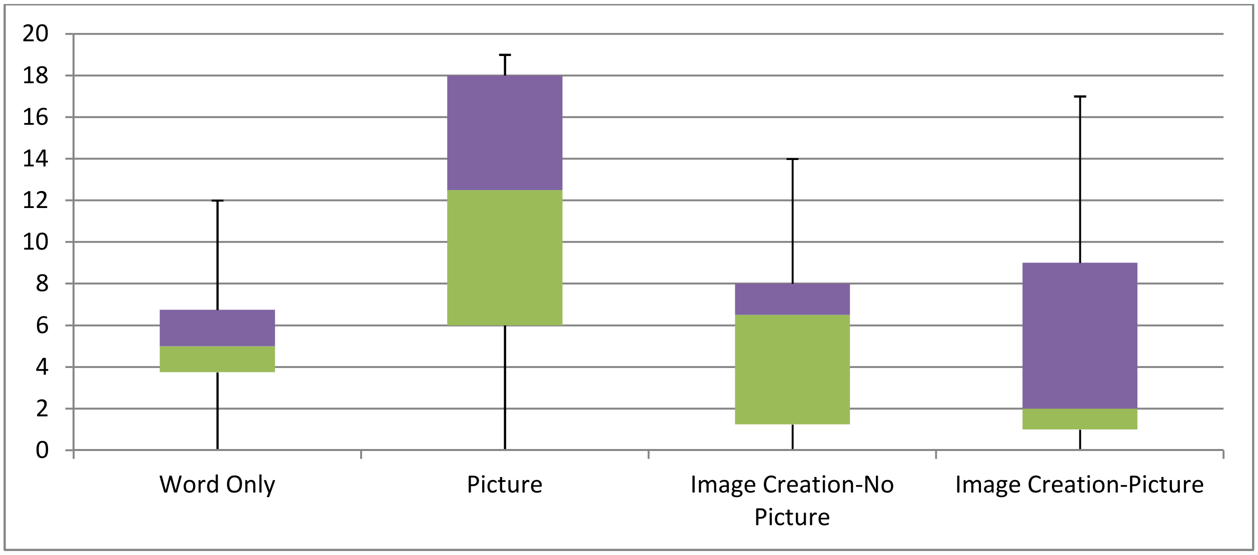


Figure 1. Box plot displaying the difference between the intervention groups' post-test scores at immediate recall.

> *"It was new for me and I kinda liked it. I loved how the pictures…It helped you remember the words."*

While the participants of the Picture Presentation method perceived their intervention favorably, I noted and coded a less than favorable perception from several participants of the fourth intervention group, the Image Creation—Picture method. More than once, I recorded that students remained positive about seeing a visual and having to draw it within 30 seconds. However, I also noted during the interview that these same participants perceived the method as demanding. When I asked one student if she liked the method of her intervention, she expressed the following:

> *"Yes. It was challenging. It helped me understand the meaning of the words."*

Another participant in this same intervention group, the Image Creation—Picture method, expressed that the method as taxing:

> *"I didn't like having to sit that long."*

Delayed recall acquisition. Two weeks following the interventions, at the time of the delayed recall post-test, a different trend emerged in the results of the compared means compared to the immediate recall post-test, which was 24 hours following the interventions. This trend reflected that the Picture Presentation method had the greatest mean, followed by the Image Creation—No Picture, but the results differed from the immediate recall results in order of the last two interventions. Thus, the following pattern unfolded for the delayed recall acquisition: Picture Presentation > Image Creation—No Picture > Image Creation—Picture > Word-only. The means (with the standard deviations in parentheses) for this pattern were 8.63 (6.07), 3.83 (3.92), 3.78 (5.74), and 2.63 (2.97), respectively. These relationships are visually presented in Figure 2.

The interviews may further support the difference in the trend of the retention of the science vocabulary terms at the time of the delayed recall post-test. I documented a notable theme during the participant interviews that indicated several of the students perceived the Word-only intervention as ineffective. When I asked if their perception of the method was favorable, a participant in this intervention group responded negatively:

> *"Didn't like it. I needed more information. It did nothing to help me remember the vocabulary. Show us a video or something."*

Another common theme was the students' perception that a two-week time lapse between the intervention and the delayed recall post-test was a significant amount of time with no reinforcement to aid in the retention of the vocabulary definitions. One participant in the second

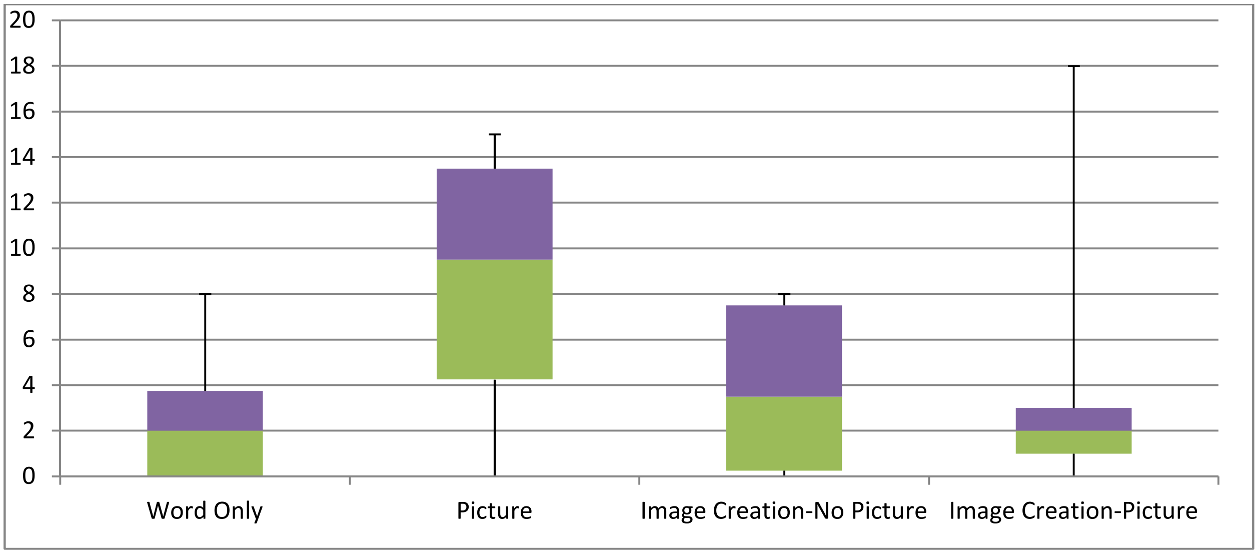


Figure 2. Box plot displaying the difference between the intervention groups' post-test scores at delayed recall.

intervention group, the Picture Presentation method, expressed this perception:

> *"If we didn't stop for the two weeks, if we would have done it every day, I would have remembered."*

The participants in the first intervention, the Word-only method, further expressed negative perceptions regarding the retention of the science vocabulary terms. A repeatedly coded concern was that these participants did not feel they would remember the information presented during their intervention. When I asked what was helpful in the method to remembering the vocabulary and if they would remember the vocabulary definitions, participants commonly responded in the negative:

> *"Nothing helped me. No."*
>
> *"Nothing helped me. I just tried to remember and I couldn't. I don't know."*
>
> *"Nothing helped me. I don't know. More information."*

Summary

I gave a science vocabulary definition pre-test to participants prior to any interventions occurring during this study. I required participants to generate the definitions of 25 predetermined fifth grade science vocabulary terms. Following the pre-test, I selected 16 of the science vocabulary terms for the ensuing interventions and post-tests. I picked these 16 terms based on their high frequency of incorrect responses on the pre-test. I randomly assigned all participants to one of four intervention groups, where they encountered a method to aid in their retention of these 16 vocabulary terms. Following the interventions, I administered two separate post-tests to measure acquisition and retention: the immediate recall post-test, which I administered 24 hours following the interventions, and the delayed recall post-test, which I administered two weeks following the interventions.

I conducted one-way ANOVA data analyses to compare relationships in the data. I conducted a one-way ANOVA to compare the results of the pre-test to the results of the immediate recall post-test, as well as the delayed recall post-test. I also conducted a one-way ANOVA to compare the results of the post-test scores for the four intervention groups. Although I found nothing statically significant when I compared the one-way ANOVA results of the pre-test scores to both recall scores—the immediate recall post-test scores and the delayed recall post-test scores—the means of both of the recall post-tests increased from the mean of the pre-test, indicating that the four intervention methods aided in the increase of the post-test scores. Likewise, I found nothing statistically significant for any intervention comparison post-test. For immediate response recall and delayed response recall, however, the mean for the Picture Presentation method emerged as the greatest mean of all four intervention methods, indicating that the participants in this intervention group benefited the most from their intervention method.

The open-ended survey results further indicate that the students from the Picture Presentation intervention benefited greatly from their intervention. Many participants in this intervention group expressed positives feelings toward their intervention method; participants saw the benefit of viewing a picture related to the vocabulary they needed to remember. Many said that the method of their intervention made them better able to remember the vocabulary in the long term, which supported the results of the delayed recall assessment.

Chapter 5: Discussion and Implications

Introduction

Students must be able to learn vocabulary to succeed in their academic career. The vocabulary introduced in the content disciplines, such as science, poses challenges for students. Students must learn complex, sophisticated, content-specific vocabulary that they do not use in everyday conversations. This study aimed to explore the correlation between utilizing visuals and the acquisition of science vocabulary. I was able to answer my research question, "Does the use of effective visuals enhance science vocabulary acquisition and the resulting expression of that vocabulary?" with a confident "yes." The quantitative and qualitative analyses of the data support the use of effective visuals in the classroom to aid in the acquisition of science vocabulary.

The analyses indicated this correlation by measuring the most effective, efficient use of science vocabulary visuals, based on four interventions that graduated in depth of processing.

Interpretation of the Results

Pre-test results compared to post-test results. Quantitative analysis of the data uncovered no significant statistical difference between the pre-test scores and either post-test set of scores—the immediate recall post-test and the delayed recall post-test. In other words, after I administered a one-way ANOVA on the data for the pre-test and post-test scores, the resulting probability value returned greater than .05 ($p > .05$). I was able to use the mean scores, however, to compare the pre-test and both post-tests. Participants' means rose by a difference of 98.59% from the pre-test to the immediate recall post-test. Similarly, participants increased their mean from the pre-test to the delayed recall post-test by a difference of 68.48%. The increase in these means indicates that the use of the intervention methods, as a whole, positively affected the participants' abilities to generate meaningful definitions for the science vocabulary terms from the intervention.

The cumulative total score for all pre-tests was considerably lower than the cumulative total score for both of the post-tests, supporting that the participants gained knowledge from the interventions. Participants struggled to make sense of the new science vocabulary presented to them, as initially indicated by a low cumulative score for all of the pre-tests. I administered this test to gauge student knowledge of the predetermined vocabulary terms. Following the pre-test, I found that the majority of the participants had little to no knowledge of the definitions of these terms. Following the interventions, however, both post-test scores reflected a gain in knowledge, as indicated by an increase in the cumulative total scores for the post-tests. The students did not participate in any other interventions outside of this study which would justify the increase in the post-test scores from the pre-test scores. Therefore, the interventions are likely responsible for the gain in knowledge.

Additionally, participants expressed positive feelings towards their interventions, reinforcing the finding that the interventions increased student knowledge of the vocabulary terms. While no questions on the interview survey specifically addressed participants' perceptions of their performance on the pre-test compared to either post-test, most participants were eager to cooperate with the study, which could have resulted in enthusiastic attitudes, consequently contributing to the increased means on both post-tests.

Imagery and depth of processing. For this study, the mean scores on the post-tests demonstrated that the participants in the Picture Presentation group scored the highest, followed by those participants in the Image Creation—No Picture group, which indicates that visuals are an important component of vocabulary acquisition. However, the immediate recall data and the delayed recall data did differ in one interesting way. At the time of immediate recall, participants in the Word-only group followed the Image Creation—No Picture group, scoring a greater mean than those in the Image Creation—Picture group. The delayed recall data contradicted this pattern, as the participants in the Image Creation—Picture group led with a greater calculated mean than those in the Word-only group.

I utilized the interventions based on a progression of depth of processing. Orally presenting the vocabulary words (Word-only method) required less processing than the next intervention, in which I orally presented the vocabulary the vocabulary words with an accompanying picture (Picture Presentation method). I followed the Picture Presentation method with even more processing in the following intervention, in which I orally presented the vocabulary and required participants to imagine a mental picture of it and draw that picture on paper (Image Creation—No Picture method). Finally, I proceeded to the greatest demand of processing in the interventions, in which I orally presented the vocabulary, showed a visual representation of the definition of those words, and required participants to recreate that visual on paper (Image Creation—Picture method). Based on this depth of processing progression and trends in the results, participants were able to manage a slight challenge in their processing at the time of immediate recall, as indicated by the Picture Presentation intervention producing the greatest cumulative mean. Students were also able to achieve an even more challenging level of processing, as the Image Creation—No Picture intervention produced the next greatest mean. Processing then dropped to the lowest indicator, that being the Word-only intervention. The participants of the Image Creation—Picture intervention did not generate the greatest number of correct responses on the post-test. The inability to produce a greater mean for this intervention could be indicative of the added requirement to reproduce the visual that was presented. This added depth of processing could easily have distracted the participants from the main objective: the retention of the vocabulary definitions.

The pattern that emerged from the immediate recall data does, however, support that the use of visuals did produce greater retention of the definitions. The results of the "first place" Picture Presentation intervention and the "second place" Image Creation—No Picture intervention suggest that student-produced visuals, as in the case of the Image Creation—No Picture intervention, as well as given visuals, as in the case of the Picture Presentation intervention, are more effective than no visuals at all, as the Word-only intervention followed behind these other two interventions in total mean scores.

As I previously noted, the pattern that emerged from the delayed recall data differed slightly from that of the immediate recall data. In the case of the delayed recall data, the pattern of the results developed identically to that of the immediate recall data but changed following the "second place" intervention. The delayed recall pattern progressed as Picture Presentation > Image Creation—No Picture > Image Creation—Picture > Word-only. The results from the two-week delayed recall indicate that student retention over time is possible even after only one exposure to new vocabulary terms. This data also supports the finding that in the context of student delayed recall, the use of visuals, whether given visuals or student-created visuals, are more effective than presenting new vocabulary orally only.

Relation of the Results to the Literature

The results of this study not only corroborate the challenges educators face when introducing new science vocabulary, but also corroborate the benefits of utilizing visuals as a means to engender understanding of this difficult-to-understand academic language.

Paivio (2010) states that dual coding is the inclusion of both verbal and visual coding in all cognition. This study supports this theory in that the use of visuals led to vocabulary acquisition. Participants from the interventions utilizing visuals consistently generated a greater percentage of the scientific vocabulary terms, both at the time of immediate recall and the time of delayed recall. These results should encourage educators to utilize effective forms of visuals when introducing new vocabulary, particularly in the content disciplines, such as science. Elementary students' textbooks are full of science vocabulary terms, which are a subset of academic language, and such terms are more sophisticated than those of any other content area (DeLuca, 2010). The present study corroborates this view through the pre-test data; the participants struggled to make sense of the terms, much less generate a definition of them without an intervention. However, following the interventions utilizing a visual, including participant-generated visuals, participants increased their knowledge compared to the initial pre-test measurement.

Along with the challenge of introducing complex academic language, educators face the daunting task of sparking interest in a discipline that may not appeal to many students; they fail to find relevance in the discipline of science (Aschbacher et al, 2013). This study indicated that the use of visuals contributed to a positive attitude concerning the content and the methods of intervention. Given that the use of visuals can create a more positive climate for the student, connect the meaning to the word, and aid in its mastery (Cohen, 2012); educators and students alike would benefit from their use. The participants of this study repeatedly stated in the interviews that they liked having the use of the pictures in their interventions.

Recent research suggests that student-created visuals are beneficial and have the potential to bring meaning (Rowsell et al, 2012). I required the participants involved in the Image

Creation—No Picture intervention to imagine a mental picture of each vocabulary term from their intervention. These participants then generated that visual on paper; they drew their mental pictures in an effort to connect the verbal codes given to a visual code. These participants consistently scored higher on their post-test measurements than the participants who were given only verbal clues and the participants who were required to recreate a given image onto paper. This evidence supports the research that student-created visuals are indeed beneficial and have the potential to bring meaning (Rowsell et al, 2012).

Cohen and Johnson (2012) cited the need for further research on the depth of acquisition of science vocabulary in in the context of instruction utilizing visuals. The interventions in this study attempted to meet this need. I designed them to challenge the participants to produce wholly self-generated definitions of the vocabulary in their interventions. The participants accomplished this task by linking verbal codes to visuals codes to enhance learning, considering unknown academic language, remaining positive about a discipline they may not particularly favor, and producing visuals that brought life to the vocabulary presented.

Biblical Integrative Component and Implications

Many times, educators feel rushed to plow through the curriculum or lessons to fit everything into the day. As a result, they rush students through their work to move on to the next curricular item. The teacher models this rushed behavior, and, consequently, creates the mentality of charging through the assigned tasks for the sole purpose completing them without giving thought to real learning or knowledge transfer. Students would benefit greatly from more effective, creative activities to assist them in the uncovering of their learning. Using visuals in the introduction of unfamiliar academic language, as well as providing the time necessary for student-created visuals, would aid in the development of cognition. Creative, engaged educators should consider the words of Paul when he writes, “We have different gifts, according to the grace given to each of us. If your gift is prophesying, then prophesy in accordance with your faith; if it is serving, then serve; if it is teaching, then teach” (Romans 12:6-7, New International Version). God calls educators to the profession of teaching and equips them with the gifts necessary to complete that calling, to do that work, “…with all your heart, as working for the Lord, not for human masters” (Colossians 3:23). Educators should ensure their work is as unto the Lord, and students should strive for this same goal. If they work together to learn and to gain knowledge, educators and students can have an enriching relationship.

Believers can find opportunities for these enriching experiences through the use of God’s gift of sight. He has personally handcrafted the backdrop to life; each morning He paints a new canvas for pleasure. In this sense, for believers, God is the artist and His followers are the consumers of His handiwork, should they choose to engage. He provides exciting visuals for His children to enjoy and, perhaps, learn from in the process. Educators share this possibility of providing exciting visuals for their students to enjoy and, perhaps, learn from in the process. Students can gain knowledge from the use of visuals, find the experience enjoyable, and even confront difficult concepts, should they choose to engage. Students can also testify to the effectiveness of visuals because they experience them. I John 1:1 is a reminder to the believers that they proclaim what they experience. John states, “That which was from the beginning, which we have heard, which we have seen with our eyes, which we have looked at and our hands have touched—this we proclaim concerning the Word of life” (I John 1:1, New International Version). Although this verse refers to the Word and the believers’ proclamation of the Word, the principle of proclaiming experiences holds true, even when considering the topic of visuals.

Although the method of utilizing visuals can produce effective results for students, Christian educators must also consider that everyone has a sin nature. The research and theory behind the utilization of visuals may prove effective. Visuals might appeal to both teachers and students. Nonetheless, because humans have a sin nature, they draw from it. As a result, perceptions, attitudes, and, many times, effort are corrupted. Although visual strategies provide an authentic, richer form of learning for students, the Christian educator needs to be more aware that the products of learning will ever be affected by sin.

Strengths of the Study

This research study utilized a mixed-methods approach in the analysis of its data in order to investigate the correlation between the effective use of visuals and science vocabulary instruction. I analyzed both quantitative and qualitative data, considering numerical correlations, as well as participant perceptions regarding the methods and content of material presented. I used open-ended questions during the participant interviews. All participants in the sample consented to participate in the study, with only one participant excluded from the results due to consistent absenteeism. While previous studies assessed the effectiveness of visuals in the classroom, this study sought to determine student acquisition of fifth grade science vocabulary with a requirement of wholly self-generated, written definitions based on the information from the interventions.

Limitations of the Study

While I took great care to reduce any confounding variables, there were notable limitations to this study that may or may not have affected the results. The overwhelming majority of the students in the two participating classrooms were Caucasian and monolingual.

This factor limits the generalizability of the study results. Another notable limitation was the varying academic levels represented in both classrooms, which could have limited prior knowledge or abilities. Particularly notable were the students in the private school elementary grade 3/4 combination classroom; a portion of this sample consisted of third grade students. Although the third grade students encountered the same instructional objectives as their fourth grade classmates, they lacked age and experience, which could have influenced their prior knowledge and academic abilities. A final consideration in the generalizability of this study was that the target samples were from two rural elementary schools, based only on convenience. Other researchers must conduct their own studies to determine generalizability to urban school settings, but they may use this study as a launching pad for further research.

Suggestions for Future Research

One question that invites future research would be, "How many repetitions of a particular visual lead to optimal acquisition?" Several participants in this study expressed in the student interviews that with more repetition, more exposure to the visual, vocabulary acquisition would improve. Future studies should consider the use of visuals in the interventions that progress in degree of processing but also allow for more than one exposure to each vocabulary word.

Another consideration for future research would be how the amount of detail impacts acquisition. For instance, do more "real life" visuals result in better acquisition of complex terminology, or do more complex visuals benefit students' retention of knowledge? Which features should artists prioritize?

A final consideration for future research might be student learning styles. Future studies should consider the effects of visuals on students who are not visual learners. Researchers might focus on the ramifications of asking students to create a visual versus providing one for them. Asking students to create visuals can be constrictive to some, while expressive for others. Some students struggle with self-expression and creativity; they tend to be the more linear learners and express themselves in like fashion. Perhaps the use of teacher-created visuals will provide mental pictures to which they can connect learning, but asking them to produce their own visuals might not only make them uncomfortable, but it might also provide them with a sense of failure from the beginning.

Appendix A

Science Vocabulary Pre-test

Write the definition for each of the following words:

1. mass:

2. evaporate:

3. transpiration:

4. condensation:

5. precipitation:

6. runoff:

7. conduction:

8. convection:

9. radiation:

10. jet stream:

11. latitude:

12. hemisphere:

13. digestion:

14. respiration:

15. circulatory system:

16. estuary:

17. plankton:

18. grassland:

19. nutrients:

20. ecology:

21. ecosystem:

22. producer:

23. consumer:

24. decomposer:

25. genetics:

Appendix B

Science Vocabulary Definition Three-Point Rubric

Score	Description
3	The student response • ***Is proficient.*** The definition provided is clearly stated and adequately represents the meaning of the vocabulary word
2	The student response • ***Is partially developed.*** The definition is weakly organized in one or more of the following ways: o Information may be presented in a random manner o Information may be presented indicating mistakes in understanding of the vocabulary term o Information is limited in the definition
1	The student response • ***Is minimal.*** The definition omits necessary elements needed to interpret a comprehensive understanding
0	The student response • ***Is inconsequential.*** The definition is either incorrect or not provided

Appendix C

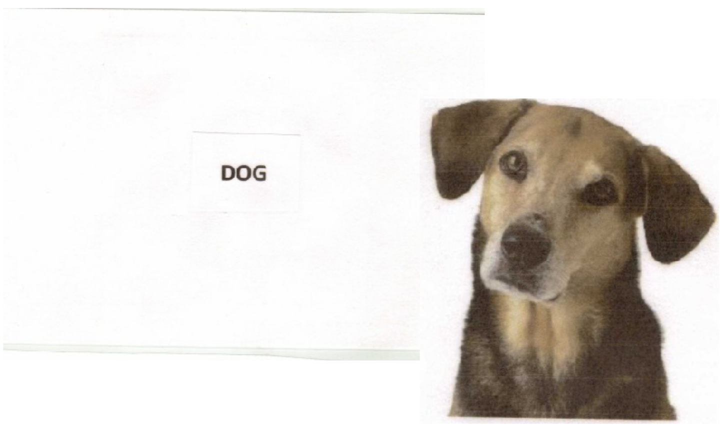
Interview Questions

1. Did you enjoy the method used to remember the vocabulary?
2. What did you like/not like about it?
3. What was helpful in remembering the vocabulary?
4. Did you use something else to help you remember the vocabulary? If so, what?
5. Do you think you will remember the vocabulary?
6. What would have been more helpful in remember the vocabulary?

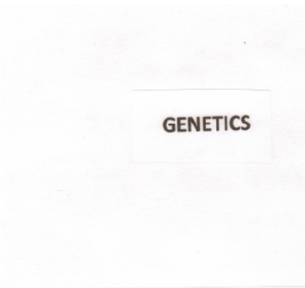
Appendix D

Sample Picture Cards

Test Card



Sample Science Vocabulary Cards



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